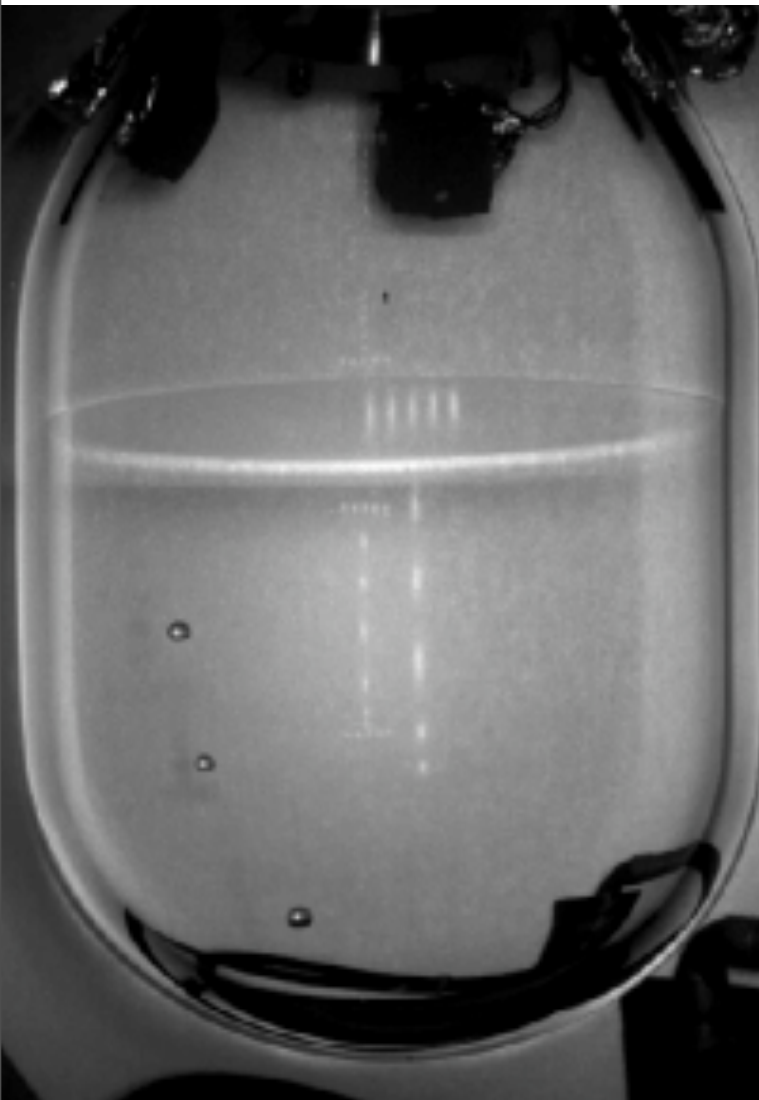


COUPP-60 NuMI Commissioning

Hugh Lippincott
All Experimenter's Meeting
Nov 7, 2011

Searching for Dark Matter with Bubble Chambers (COUPP)

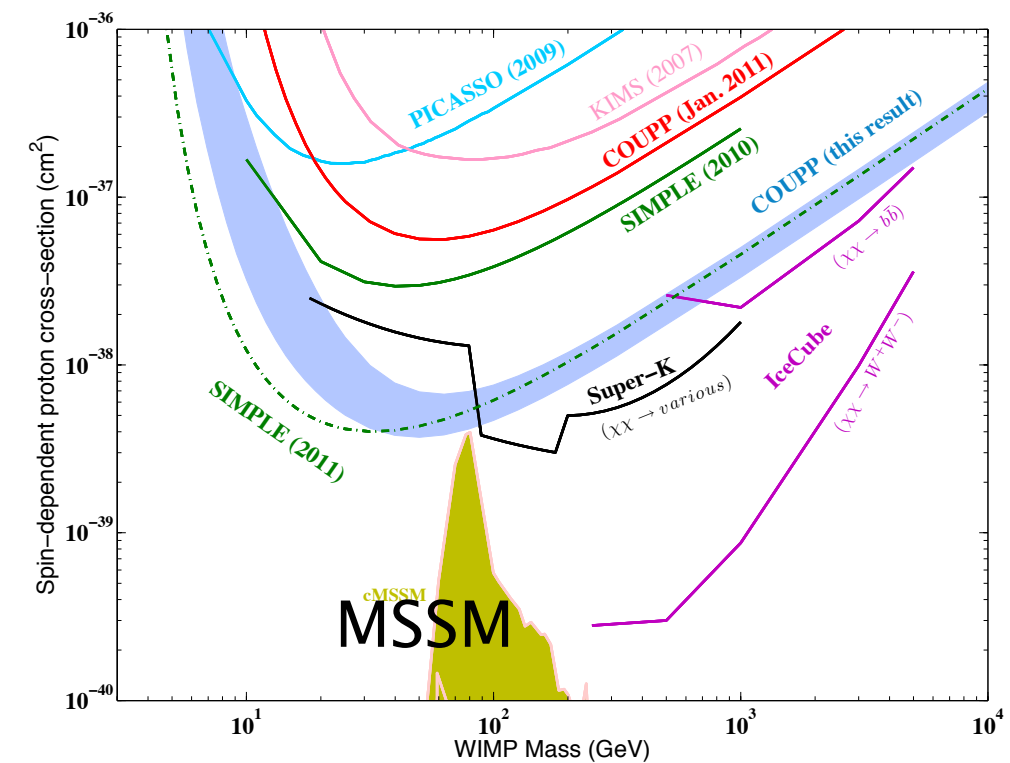
- Exploit physics of bubble nucleation to discriminate against background gammas and alphas: successful 2009 run of small chamber demonstrated potential to reach zero background.
- Scalable: 60-kg being commissioned now; 500-kg and 16-ton (DUSEL) versions under discussion.



Neutron scattering background event in 4-kg chamber



Construction of 60-kg chamber



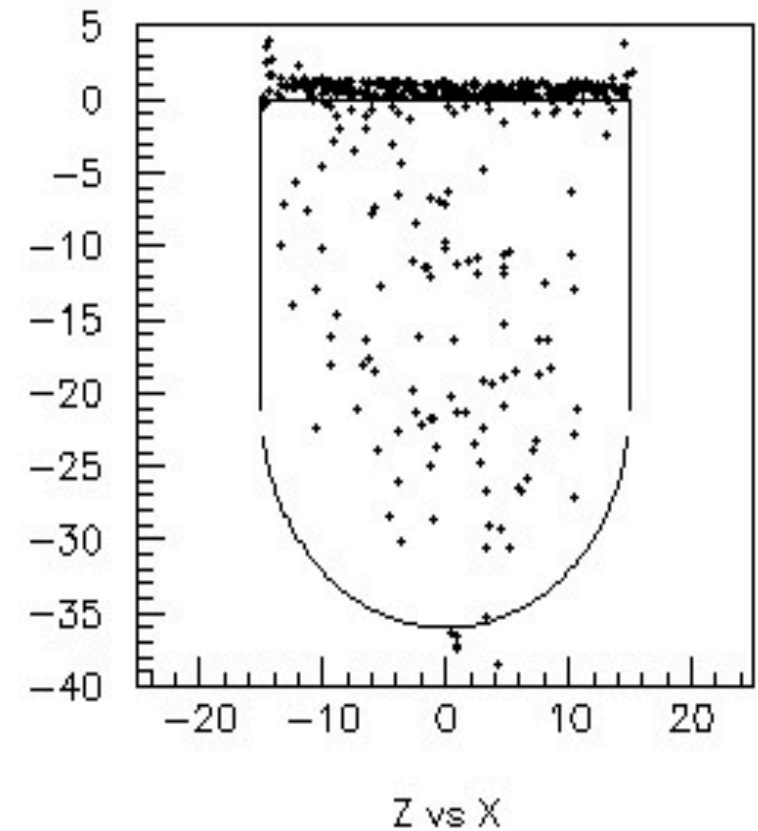
Physics reach for spin-dependent Weakly Interacting Massive Particle (WIMP) interactions on protons—COUPP is now sensitivity leader in this channel, will soon probe SUSY models

COUPP-60 Commissioning

- First run at NuMI took place July–August, 2010
 - Achieved background goals
 - Demonstrated the existence of discrimination between alphas and nuclear recoils in COUPP-60
 - Exposed serious problems with optics and chemistry
- Reported to AEM by C. Dahl and A. Sonnenschein on Aug. 16 and Oct. 18, 2010

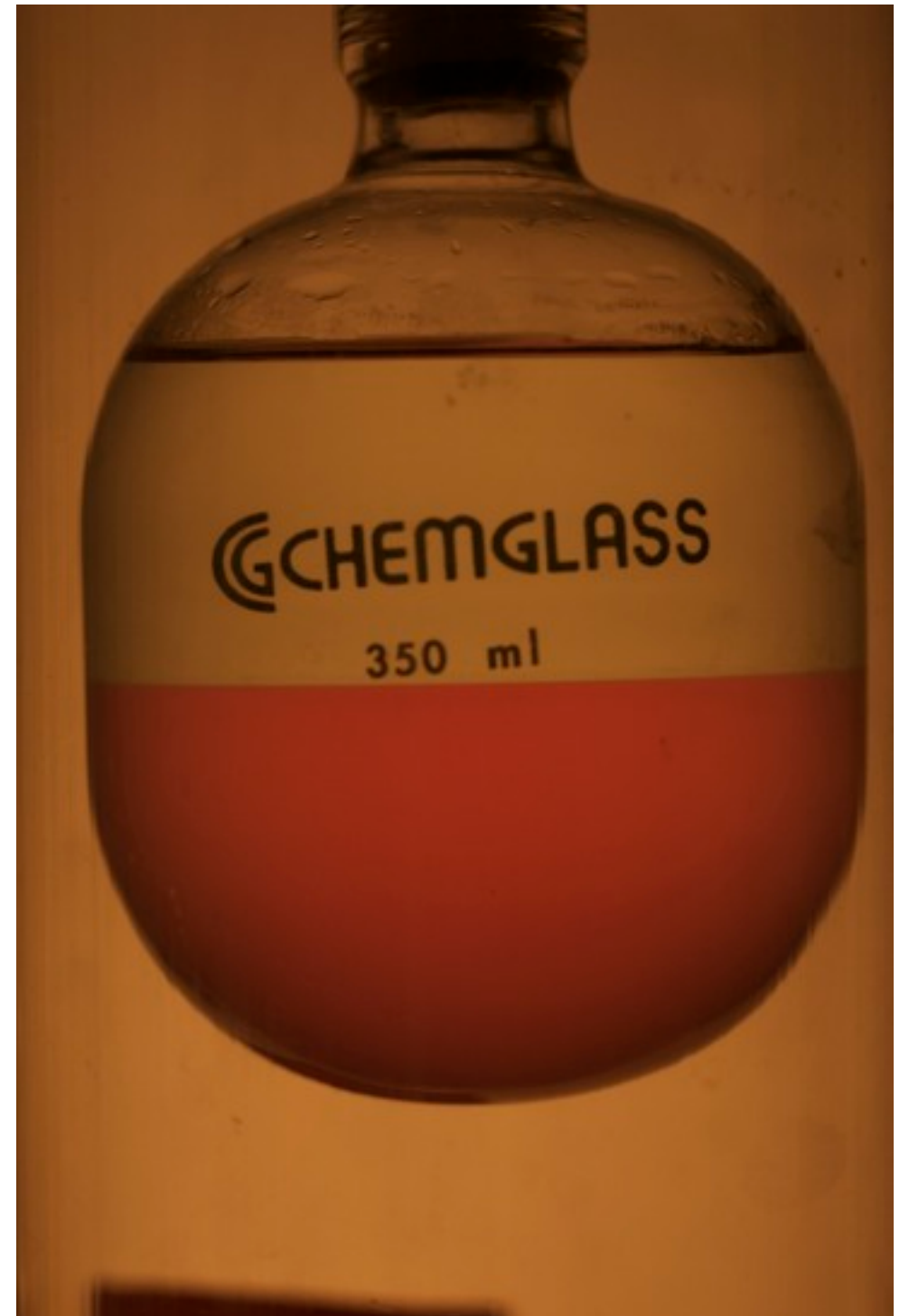
2010 run issues

- Optics
 - Two light sources produced shadows
 - De-lamination of lenses giving glare
 - Dark spots at bottom
- Chemistry
 - Progressive darkening of the images rendered data taking impossible after a month
 - Excessive surface boiling led to unacceptable loss of livetime given recompression time for each bubble



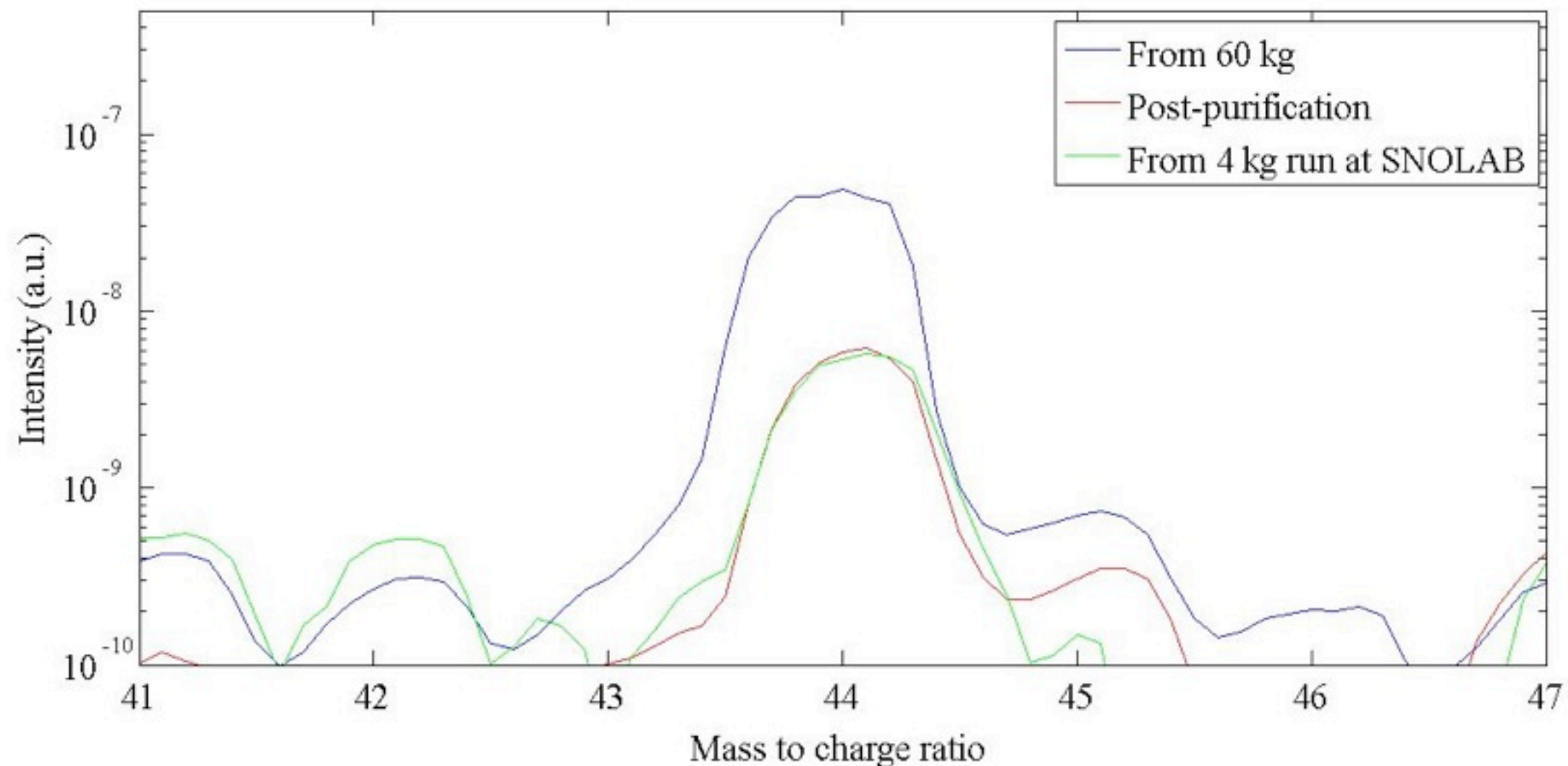
Chemistry studies

- Darkening traced to photodissociation of the $\text{CF}_3 - \text{I}$ bond
 - Free iodine gives the color
- Still not clear why previous chambers have not seen significant darkening
 - Evidence that steel inhibits the reaction
 - Potentially related to impurity as a seed
- With help from Ilya Shkrob, a chemist at Argonne, we decided to add sodium sulfite to the water
 - The sulfite transfers equilibrium to move iodine into the water and ionize it (colorless)



Chemistry studies

- Surface boiling
 - Gas analysis of the fluid used found more than 1% contamination by CO_2
- Additional purification step using a molecular sieve and a getter eliminates CO_2 by at least an order of magnitude (limited by sensitivity of RGA)

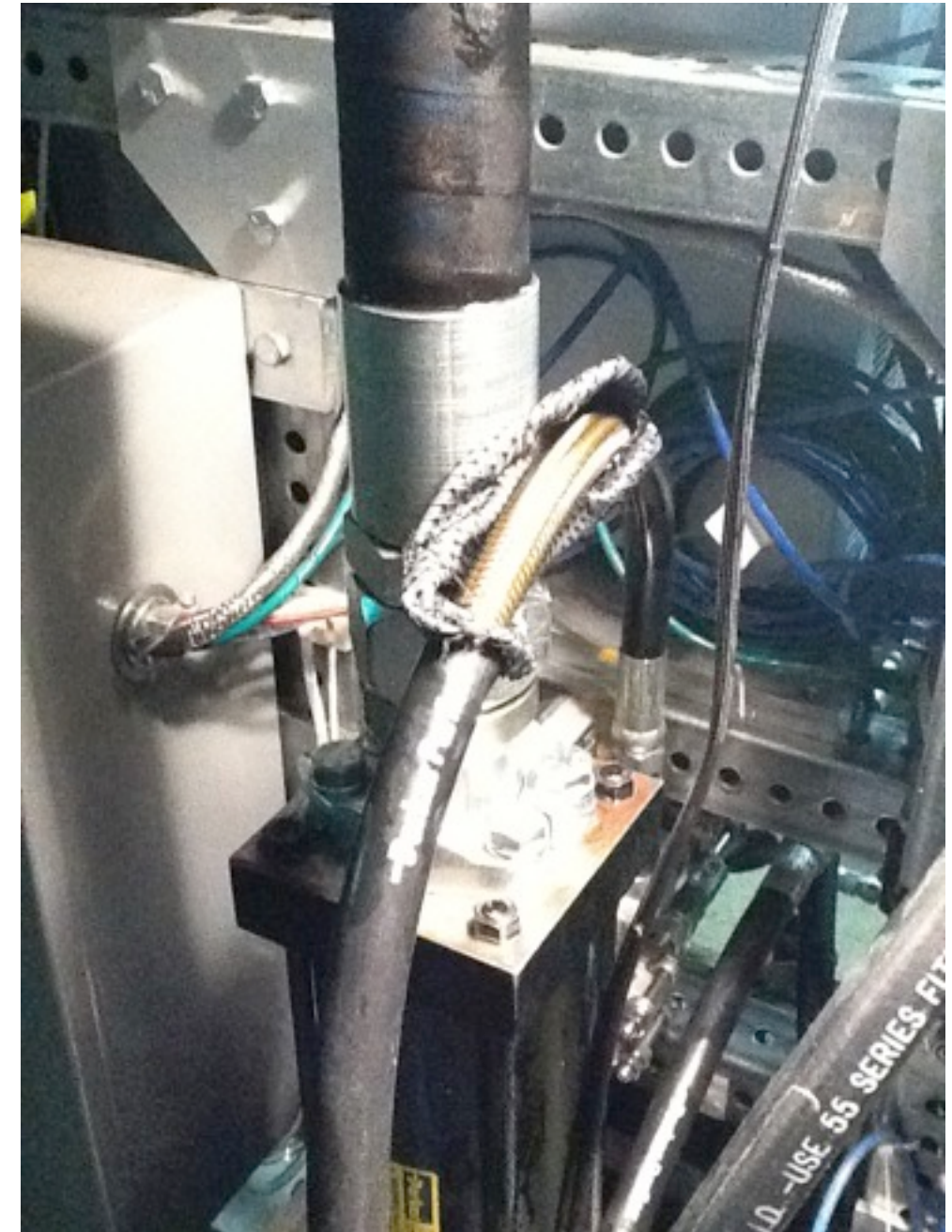


New commissioning run

- Optics – new LED array to improve shadowing and decrease overall light exposure
 - Silicone rubber to couple lenses to viewport
- Addition of sodium sulfite to the water to prevent darkening
- New purification step
 - Filled detector with the same batch of CF_3I after purification (historically we have not reused fluids)

Technical delays

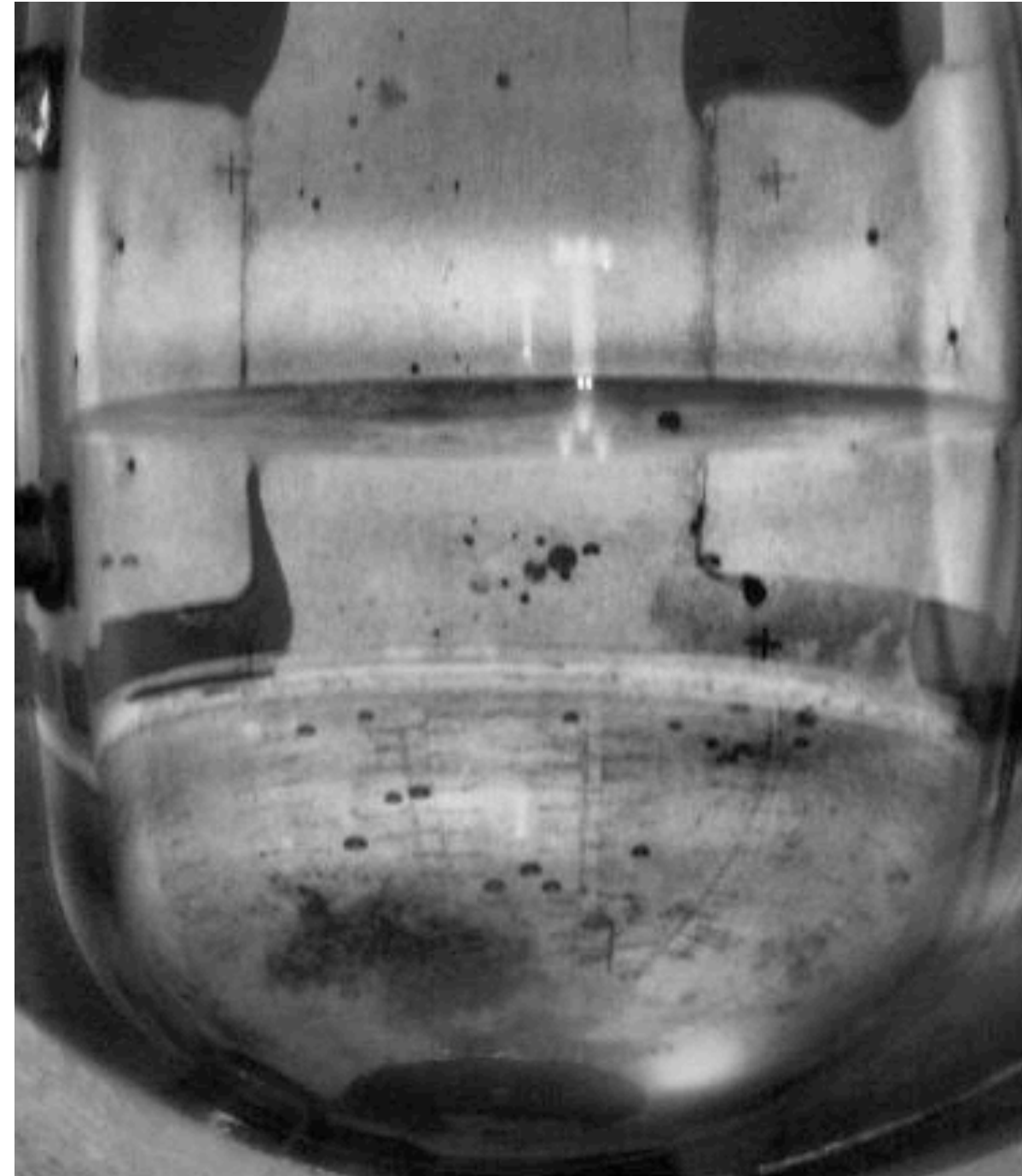
- In July, just before doing the first cycles, a hydraulic line burst
 - Problem traced to incorrect installation
 - Re-installed the entire hydraulic piping system
- Also issues with as-built drawings of pressure vessel



Finally able to run Oct. 7!

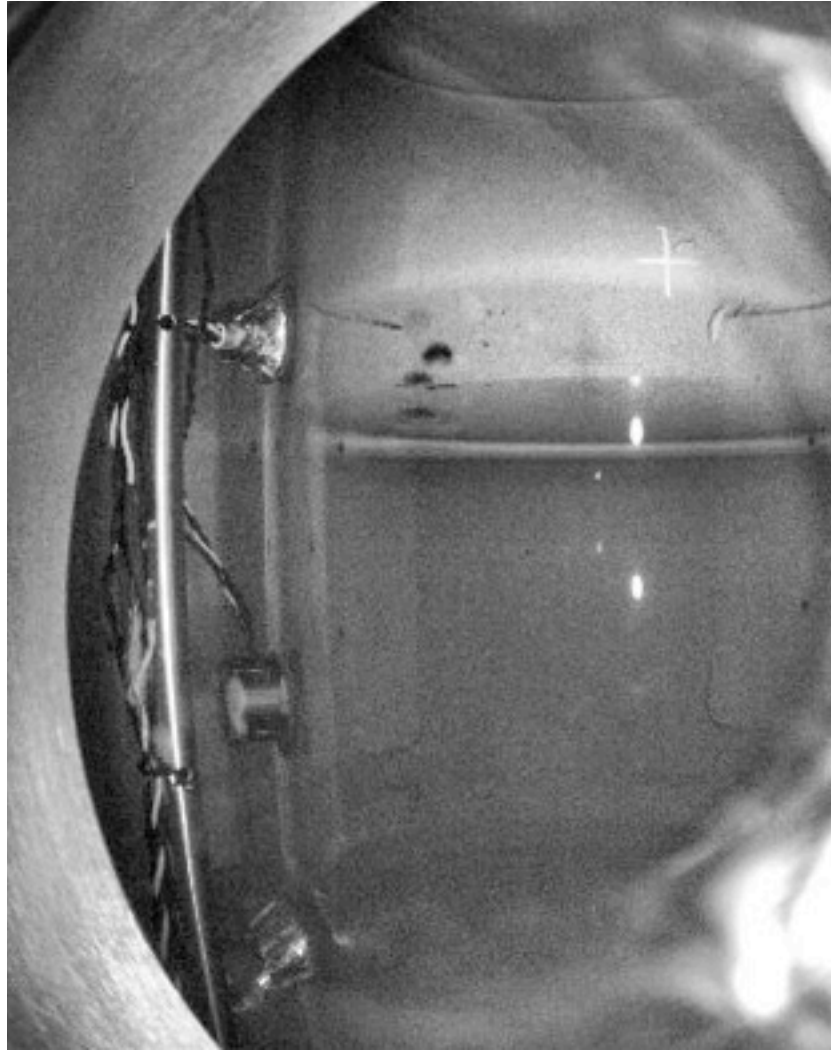
Optics problems

- Shadowing no longer present
- No evidence for de-lamination of lens
- We do observe a failure of the retro-reflector (the large armpits, the many black spots)
 - Too much cycling of the hydraulic fluids
 - No effort made to clean or replace since the last run



Darkening

Last year after 25 days



This year after 50 days



- Less than 10% darkening after 50 days of light exposure
 - No significant difference between the water and CF_3I
 - The observed change is likely related to the LEDs/cameras

Surface boiling

| | Threshold | Total rate | Surface rate |
|----------|-----------|------------|--------------|
| 2010 run | 7 keV | 200 cts/hr | 150 cts/hr |
| | 10–15 keV | 115 cts/hr | 92 cts/hr |
| 2011 run | 7 keV | 60 cts/hr | 15 cts/hr |
| | 8 keV | 56 cts/hr | 9 cts/hr |
| | 17 keV | 30 cts/hr | 7 cts/hr |

Surface boiling

- Improvement by an order of magnitude in surface rate
- About a factor of 4 improvement in total rate (over 50% live at 17 keV despite longer than usual compression times)
- Rate dominated by the NuMI beam (20/hr)
 - About 10/hr coming from cosmics and internal backgrounds
- Still a little hot for comfortable running
 - Evidence from past chambers that high rates can lead to an unstable running condition
 - It is likely that the 30 events/hr we get from NuMI and cosmics prevent assessing the true stability of the chamber

End of run

- Last Friday at 5 pm, a leak formed somewhere on or around the pressure vessel
 - We could not valve off the pressure vessel from the location of the leak
 - Leak closed by itself with reduced pressure (~125 psia)
- Reduced the temperature over the weekend
 - The quartz inner vessel can now survive if the leak reopens
- This morning, traced the leak to a flat gasket seal between the viewport window and the pressure vessel

Next steps

- We have demonstrated that we can prevent darkening
- Surface rate reduced by an order of magnitude, factor of 2–3 better than a goal of 500/day
 - We will continue chemistry work, and we have found a supplier of higher purity CF3I
 - Limited by the unavoidably high rates in the NuMI tunnel
- We must decide whether there is anything more to be gained by further running at NuMI
- Other improvements (pressure vessel, low radioactivity piezos)
- Pack up and move to SNOLAB

Thanks to

- Ilya Shkrob and the analytical chemistry group at Argonne
- Anna Pla-Dalmau, Jennifer Thompson for local chemistry help
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